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(54) Regeneration of hygroscopic material in a laundry drying appliance

(57) A method of operating a laundry drier for regeneration of hygroscopic material (9) contained in a container (8), which is alternatively, connectible into a closed circuit (8 and 2, 3, 4, 5, 6) for drying air circulated through a laundry drum of the drier and an open circuit (8 and 13, 15, 12) for drying air passed through the container to regenerate the hygroscopic material, comprises carrying out an operating phase for regeneration of the hygroscopic material after completion of the appliance operation for drying of the laundry. The air passed through the open circuit can be heated by a heat pump (22) in an initial part of the regeneration phase and additionally by an electric heater (21) in an end part of that phase.

Fig.1

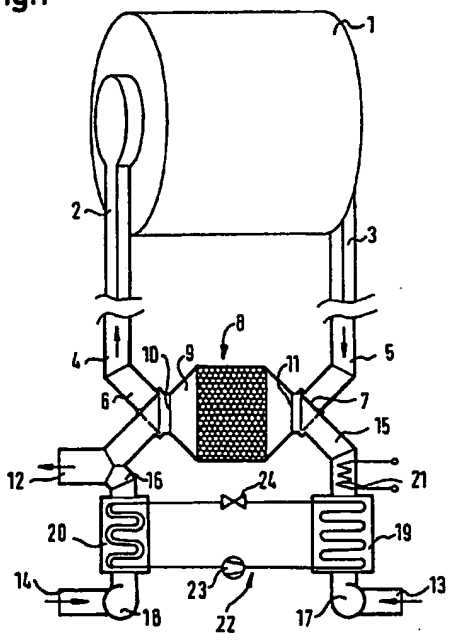

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Fig.1

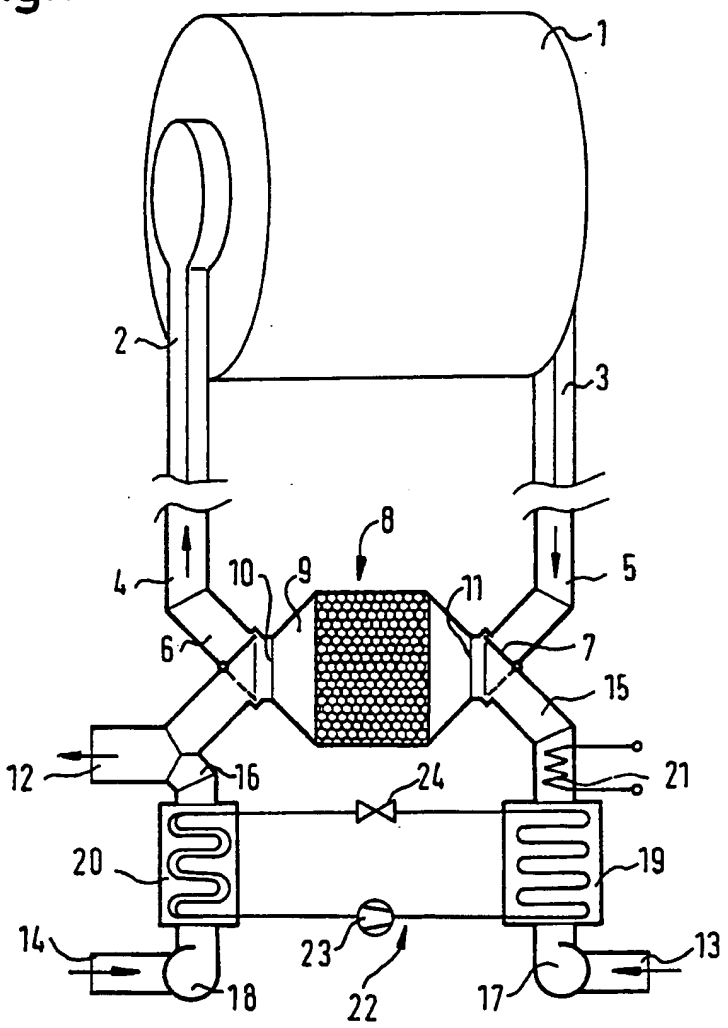
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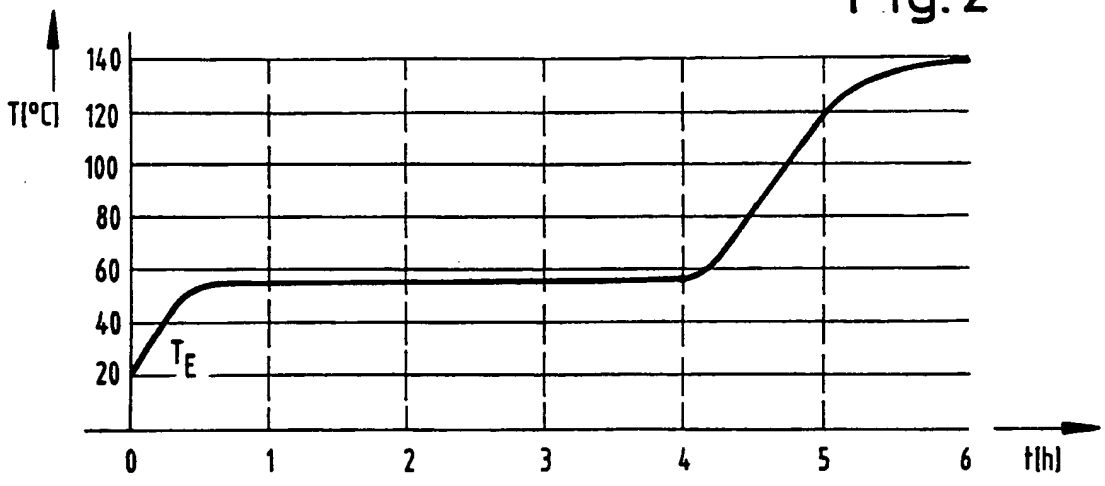
Fig.2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REGENERATION OF HYGROSCOPIC MATERIAL IN A LAUNDRY DRYING APPLIANCE

The present inventon relates to a method of operating a laundry drying appliance, in particular for regenerating hygroscopic material therein, and to a laundry drying appliance in which such a method may be performed.

A method of regenerating hygroscopic material in a laundry treatment machine is described in German published specification 36 26 887. However, in that case a process (drying) air circuit and a regeneration circuit are effective in alternation during drying of the laundry. Heating of the drying air by electrical heating equipment is also provided for the process air circuit. A further electrical heating equipment is provided for the regeneration circuit in order to expel moisture, which has been absorbed in the interim by the hygroscopic material, in the shortest possible time so that the material is again available immediately for a further, following drying section. In order that the drying process can take place in tolerably short limits even while maintaining the slow-running operations during water absorption and water delivery by the hygroscopic material, support of the drying and regenerating processes by additional heating equipments is essential.

There thus exists a need to effect a saving of energy in the case of drying with use of hygroscopic material and regeneration of the material.

According to a first aspect of the invention there is provided a method of regenerating hygroscopic material which is arranged in a container in a channel section of a closed process air circuit in a laundry drying appliance, the channel section being connectible, for regeneration of the hygroscopic material, into an open regeneration circuit which contains heating equipment, wherein the program section for regeneration takes place following the program section for drying of the laundry.

It has proved that either the duration of the entire drying process becomes too long for the user or too much heat energy must be expended for the drying and regeneration process when drying and regeneration sections alternate. More favourable is a continuous drying process with the use of hygroscopic material, which on absorption of water, delivers absorption heat which can be fed to the drying process for expulsion of moisture from the laundry. For that reason, heating of the process air can be dispensed with during the drying process. In total, a better basis for the possibility of energy-saving in the appliance results.

Hygroscopic material having an entry temperature to the regeneration of 40 to 70°C for the duration of more than half the regeneration time has proved to be particularly advantageous. In that case, entry temperature signifies the temperature of regeneration air conducted to the hygroscopic material for the purpose of moisture removal. The regeneration time is the time required for restoration of the original state of the hygroscopic material. Such material is the most suitable for rapidly picking up moisture from the drying or process air and in appreciable quantities and in that case still delivering heat energy to a usable extent.

In a preferred example of the method, the air flow and heating power of heating equipment in a first regeneration section, which is characterised by a relatively high water content of the hygroscopic material, are so dimensioned that the temperature of the regeneration air is between 40 and 70°C before entry into the container and the temperature after the exit from the container is no more than substantially 5°C above the ambient temperature. With this dimensioning of the heating equipment, it has proved that a significant regeneration of the hygroscopic material can be realised with least possible energy expenditure in an acceptable time, so that the hygroscopic material at the end of the regeneration phase is again available for use for drying of the laundry.

The return of the hygroscopic material to the original state, in which the residual moisture in the hygroscopic material goes towards zero percent, can be achieved, in an advantageous development of the method, if the heating power of the heating equipment in a regeneration end section, which is characterised by an appreciably rising heat absorption of the hygroscopic material, is so dimensioned that the temperature of 40 to 70°C before entry into the container is gradually raised to no more than 140°C.

A significant step in terms of energy saving results if the heating equipment, which supplies the heat, contains a heat pump of low absorption power. Low absorption power can be about 150 to about 250 watts. Such heat pumps are used in domestic cooling or refrigerating cabinets. This heat pump can be used to advantage in the first regeneration section. For this purpose the heat pump

would run in effective operation and in that case deliver two to two-and-a-half times as much energy as an electrical heating element of the same absorption power.

If an electrical heater, which is switched to be effective in the regeneration end section, is provided, the hygroscopic material can after the heat treatment in the first regeneration section still be brought to a residual moisture of less than 5%. The total expenditure of energy for drying the laundry and regenerating the hygroscopic material could then be about one kilowatt-hour less per laundry treatment process than in the case of conventional laundry driers. This would mean a saving effect of approximately 35%.

It is preferable to construct the container for the hygroscopic material to be closable to be airtight at the end of the regeneration end section, otherwise the hygroscopic material can absorb moisture from freely accessible air during longer intervals between use of the container and thus present too little water absorption capacity for the next laundry drying process.

For this purpose, a respective flap, which can be moved into an open setting for the duration of the entire drying and regeneration processes and into a closed setting after termination of the regeneration process, can advantageously be arranged at each of the entry and the exit of the container.

An example of the method and embodiment of the appliance of the present invention will now be more particularly described with reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatic illustration of an air feed system in a laundry drying appliance embodying the invention; and

Fig. 2 is a diagram of entry temperature and exit temperature at a hygroscopic material container of the appliance in the course of a regeneration process.

Referring now to Fig. 1, there is shown a laundry drum 1, which is mounted to be rotatable about a horizontal axis, of a laundry drier. Introduced articles of laundry can tumble around in the drum whilst air enters the drum from an inlet channel 2, flows through the drum and departs by way of an exhaust air channel 3. By contrast to conventional laundry driers, the air feed channel 2 does not contain any electrical heating equipment. A blower (not shown), which serves for movement of the air through the channels and the drum is, provided in the air feed channel 2. The drive motor dissipation heat of the blower can be transferred into the air feed together with dissipation heat from the drum drive motor.

A feed channel 4 is connected to the air inlet channel 2 and a waste channel 5 to the exhaust air channel 3. The channels 4 and 5 are connected during the drying process, for which purpose two flaps 6 and 7 are set into the positions illustrated in dashed lines, with a container 8 for hygroscopic material 9. The moist drying air issuing from the drum 1 and fed by way of the channels 3 and 5 to the container 8 is dried to a large extent by the hygroscopic material. During this drying process, the hygroscopic material delivers absorption heat which, together with the quantities of dissipation heat mentioned above, is transported by way of the inlet air through the channels 4 and 2 into the laundry drum and thereby to the laundry. This heat raises the evaporation of the moisture

contained in the laundry, so that the air issuing from the laundry can take up an increasing proportion of moisture. The hygroscopic material 9 has a high water absorption capacity with relatively high delivery of absorption heat. Consequently, the drying process lasts for a similar length of time to that in the case of a conventional laundry drier, in which the drying air is heated exclusively by electrical energy.

In a regeneration process following the drying process, an exit opening 10 and an entry opening 11 of the container 8 are connected by flaps 6 and 7, which remain in the settings shown in solid lines, respectively with an exhaust air opening 12 and an inlet air opening 13. A blower 17, which is driven by an electrical motor (not shown), a liqueifier 19 of a heat pump 22 and an electrical heating device 21 are arranged in a connecting duct 15 between the entry opening 11 and the inlet air opening 13. The cold side of the heat pump 22 is disposed in a connecting channel 16 between the exit opening 12 and a further air inlet opening 14, the inlet air of which is fed by means of a blower 18 through the collecting duct 16 to the exhaust air opening 12. In that case, the air flows along the heat exchanger surfaces of an evaporator 20 of the heat pump 22, transfers a part of its heat energy to the evorporator and passes by way of the exhaust air opening 12 back out into the ambient air. The transmitted heat energy in the evaporator 20 evaporates coolant conducted by way of a compressor 23 to the liquefier 19, which delivers it back to the evaporator 20 by way of a relief valve 24.

The functioning of the system illustrated in Fig. 1 is explained by reference to the diagram of Fig. 2. After the laundry drying process has taken place, the state shown in Fig. 1 (flaps 6 and 7 upward) is set. The blowers 17 and 18 and the compressor 23 are then switched on, whereby the heat transmission process from the ambient air, which flows into the inlet air opening 14 and is delivered back to the environment by way of the exhaust air opening 12, begins, in particular heat transmission to the warm side of the heat pump 22 and thus to the ambient air flowing through the air inlet opening 13 and into the connectinv channel 15. The ambient air heated in the liquefier 19 reaches a temperature of about 50°C and passes through the entry opening 11 into the container 8 and thus into the hygroscopic material. In that case, the heat from the inlet air is transferred into the hygroscopic material, which in its turn delivers the moisture contained therein to the exhaust air which passes by way of the exit opening 10 to the air exhaust opening 12. Towards the end of the first or initial regeneration section, which can last up to four hours, the residual moisture of the hygroscopic material reaches a value of less than 15%, which at the instant of the termination of the drying process could quite easily have been of the order of magnitude of 50%. In order to lower the residual mositure of the hygroscopic material to somewhat below 5%, the feed of further heat energy is necessary. This is provided by the switching on of the electrical heating device 21 at the instant 4h. The temperature of the inlet air entering the entry opening 11 can then noticeably increase. This increased quantity of

heat desorbs the hygroscopic material to a residual moisture content of somewhat below 5%. In this state, the hygroscopic material can serve for a new drying process. This state is reached after about 4.5 to 5 hours of regeneration when the entry temperature has reached about 100°C. Further desorption to nearly 0% is superfluous and would cost too much further heating energy, for example 1.3 kilowatt-hours.

The exhaust air from the container 8 is moist, although it can in general be distributed over 4.5 to 5 hours harmlessly in the environment of the laundry drier. If this cannot occur harmlessly, the moisture can either be conducted into the open by way of an exhaust hose or be fed by way of an additional condenser.

After the end of the regeneration process, the hygroscopic material should be sealed off against the ambient air in order to prevent it from taking up moisture from the ambient air. Tightly closing flaps (not illustrated), which are arranged at the entry opening 11 and at the exit opening 10, can serve for this purpose.

The sequence of the regeneration process can be controlled automatically by monitoring elements. Such monitoring elements can be, for example, temperature sensors close to the entry opening 11 and the exit opening 10, as well as temperature sensors which control the heat pump process and an excess temperature sensor for the protection of the heating device 21. Similarly the energy density in the inlet air can be regulated by power control of the blower 17.

CLAIMS

1. A method of operating a laundry drying appliance for regeneration of hygroscopic material contained in a container alternatively connectible into a closed circuit for air circulated in the appliance to dry laundry and an open circuit for air passed through the container to regenerate the hygroscopic material, the method comprising the step of causing the appliance to perform an operating phase for regeneration of the hygroscopic material after final completion of operation of the appliance for drying of the laundry.

2. A method as claimed in claim 1, comprising the step of causing the air in the open circuit during an initial part of the phase for regeneration to have a temperature of between 40 and 70°C before entry into the container and a temperature of at most substantially 5°C above ambient temperature after exit from the container.

3. A method as claimed in claim 2, comprising the step of progressively raising the temperature of the air in the open circuit during an end part of the phase for regeneration from between the 40°C and 70°C ahead of entry into the container to at most 140°C.

4. A method as claimed in any one of the preceding calims, comprising the step of so controlling the temperature of the drying air in the open circuit during the phase for regeneration that the hygroscopic material has an entry temperature for regeneration of 40 to 70°C for more than half the duration of that phase.

5. A method as claimed in claim 1 and substantially as hereinbefore described with reference to the accompanying drawings.

6. A laundry drying appliance comprising a container containing hygroscopic material and alternatively connectible into a closed circuit for air circulated in the appliance to dry laundry and an open circuit for air passed through the container to regenerate the hygroscopic material and means to cause the appliance to perform an operating phase for regeneration of the hygroscopic material after final completion of operation of the appliance for drying of the laundry.

7. An appliance as claimed in claim 6, comprising means to cause the air in the open circuit during an initial part of the phase for regeneration to have a temperature of between 40 and 70°C before entry into the container and a temperature of at most substantially 5°C above ambient temperature after exit from the container.

8. An appliance as claimed in claim 6 or claim 7, comprising means to progressively raise the temperature of the air in the open circuit during an end part of the phase for regeneration from between 40°C and 70°C ahead of entry into the container to at most 140°C.

9. An appliance as claimed in any one of claims 6 to 8, comprising means to so control the temperature of the drying air in the open circuit during the phase for regeneration that the hygroscopic material has an entry temperature for regeneration of 40 to 70°C for more than half a predetermined duration of that phase.

10. An appliance as claimed in any one of claims 6 to 9, comprising a low-energy heat pump to heat the drying air in the open circuit.

11. An appliance as claimed in claim 10, wherein the heat pump has an absorption power of at least substantially 150 watts and at most substantially 250 watts.

12. An appliance as claimed in claim 10 or claim 11, wherein the heat pump is controlled to operate for the entire duration of the phase for regeneration.

13. An appliance as claimed in any one of claims 6 to 12, comprising an electric heater controlled to heat the drying air in the open circuit in an end part of the phase for regeneration.

14. An appliance as claimed in claim 13 when appended to any one of claims 10 to 12, wherein the heat pump and electric heater are operable simultaneously.

15. An appliance as claimed in any one of claims 6 to 14, wherein the container is closable to be airtight.

16. An appliance as claimed in claim 15, comprising a respective closure flap arranged at each of an inlet and an outlet of the container and controlled to be disposed in an open setting throughout

the drying operation and the phase for regeneration and to be disposed in a closed setting after termination of the phase for regeneration.

17. A laundry drying appliance substantially as hereinbefore described with reference to the accompanying drawings.

Patents Act 1977 13 Examiner's report to the Comptroller under Section 17 The Search report)	Application number GB 9421857.5
Relevant Technical Fields (i) UK Cl (Ed.N) B1L LDJ, LDK, LEC F4G GCAA, GBAA (ii) Int Cl (Ed.6) B01D 53/26 D06F 58/20 D06F 58/24	Search Examiner D S LUCAS Date of completion of Search 11 JANUARY 1995
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE: WPI	Documents considered relevant following a search in respect of Claims :- 1-17

Categories of documents

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P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
X	DE 3626887 A1 (MIELE) see Claim 1 and the figures	1-17

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